Facing together new challenges : the worldwide on going R&D work for the future nuclear energy systems

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Background

- **"How can nuclear energy be used in a positive manner for the international community without being banned for military applications ?"**

- **Speech of President Eisenhower, 8 Dec. 1953 :**
  - **Legitimacy of promoting cooperation in the peaceful uses of nuclear energy,**
  - **Necessity of inspections conducted by an international agency.**

- **Then, implementation of the Treaty on the Non-Proliferation of nuclear weapons**

Has this system be efficient so far ?

- **Nuclear energy has been developped in a peaceful manner throughout the world and is used for approximatively 15% of all electricity produced.**

But :

- **Several states have still not signed the NPT,**
- **Other states must clarify their intentions,**

→ Neccesity to recently reinforce the NPT (additional protocol)

→ Think together to the future evolution of the system

Reprocessing & Recycling in France

➢ The current situation

- EDF nuclear fleet : 58 PWRs, ~400 TWh/y
- 1100 Mt_{HM} /y spent fuel discharged, incl. 100 t_{HM} MOX
- **850 Mt_{HM} UOx spent fuel (1% Pu) reprocessed**
- **Pu recycled as MOX in 20 PWRs** (900 MWe)
  1/3 MOX cores, **7,08 % Pu**, 3-batch reload, 38 GWd/t_{HM} aver.
- **100 Mt_{HM}/y MOX fuel burned**, ➔ 30 TWh
- **True HLW vitrified** (fission products + minor actinides)

A principle : "**Pu equal flows**"

- Low costs of the reprocessing option ➔ new benefits

Short Term Evolution

➢ Evolution of the MOX/UO_2 management strategy

- The **MOX parity project** : new MOX fuel management to achieve energy & economic balance between MOX and UOx fuels
- **Increased MOX Average Burn Ups** : 38 to 45 GWd/t_{HM}
- **Stabilization of separated Pu inventory** to be achieved in ~2005
- **Inventory limited** to level needed to dynamically manage the whole process

Proliferation resistance and today's recycling options

- Plutonium from LWR spent fuel is not well suited to proliferating activities
- There are easier approaches than diversion of spent fuel to proliferating activities (enrichment technologies, diversion of neutron sources…)
- Recycling Plutonium without delay limits separated stocks to the minimum required for the fuel management
- Recycling Plutonium is preferable than storing directly spent fuel elements in repositories likely to eventually become "Plutonium mines"

Mid term evolution : LWRs and Pu recycling

- major role of LWRs during the 21st century

- Investigate the possibility of Pu multi-recycling in Generation III LWRs

R&D efforts for a balance in Generation III PWRs :
Pu production = Pu consumption

- **Pu multi-recycling with New Fuel assemblies**
- **100% MOX BWR/PWR Cores**

Future Nuclear Energy Systems

- **Improved Economics, Safety & Reliability**

- **Top priority for Sustainable Development & Proliferation Resistance Goals**
  - **Sustainability**
    - Effective fuel utilization
    - Minimize & manage nuclear waste
  - **Proliferation resistance**
    - Unattractive systems/Least desirable route for diversion or theft of W-Materials
  - **Increased physical protection against acts of terrorism**

Generation IV and Nonproliferation strategy

an unique opportunity :

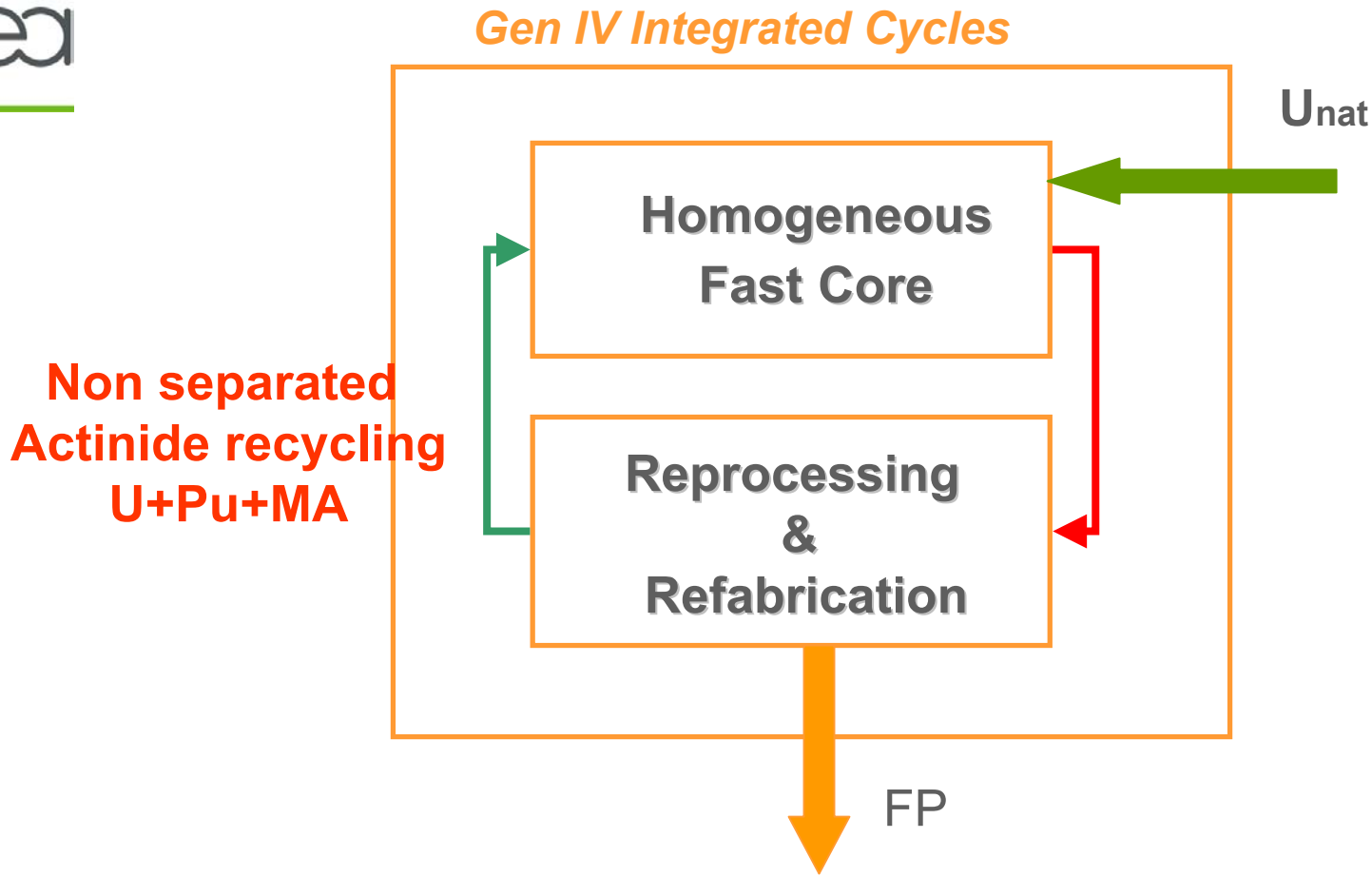
1. To adopt a comprehensive nonproliferation strategy
2. To implement measures from early design stages to operation
3. To take benefit from the experience with safety methodology
4. To take advantage from new technologies
5. To achieve a global optimisation of the future systems
6. To share the approach internationally

Generation IV Concepts selection

The ‘ fast neutron, closed cycle ’ family

- ✓ **Top-ranked in sustainability**
  - *Management of actinides*
  - *Efficient conversion of fertile uranium*
- ✓ **Rated good in safety, economics, in proliferation resistance & physical protection**
- ✓ **Gas, Na, Pb-Bi considered as different/parallel options**
- ✓ **Missions : electricity production & actinide management**

Integrated Recycling & Proliferation Resistance



Fuel cycle options for enhanced proliferation resistance

Identify technical solutions to meet these requirements

1. Attractiveness
   - Increased fuel burn-up
   - Recycling without separation of Plutonium
   - Recycling with the extraction of fission products only (« dirty fuel clean waste concept »)

2. Accessibility, physical protection
   - Integrated cycle
   - Detection techniques and controls
   - Minimisation of transports

3. Safeguardability

   IAEA safeguards, Euratom controls

Which choices, for which development strategy ?

- **How can we conciliate the voluntarist GEN IV goals of developing long lasting nuclear energy for the good of humanity, with the confidence given to the states ?**

- **What position must the states take in terms of this development strategy ?**

- **To limit the potential risk of proliferation associated to the closed cycle, widely selected in the GEN IV concepts, we must work :**
  - **for the robustness of the cycle (aim of the R&D)**
  - **for a broad international consensus (governance) :**
    - verification of **the advisability of installations**
    - **inspection of these installations**
- Some states will choose to deploy full nuclear capacities
- Others will choose to deploy reactors and to hire out the cycle services

Conclusions

- **The future reactors will be intrinsically resistant to proliferation**
- **The closed cycle will not weaken resistance to proliferation**
- **The states will be free to choose their development strategy for reactors-cycle systems**
- **An international consensus must be reached and based on a system of controlling guarantees which must be the central key in the fight against proliferation**